PATENT ABSTRACTS OF JAPAN

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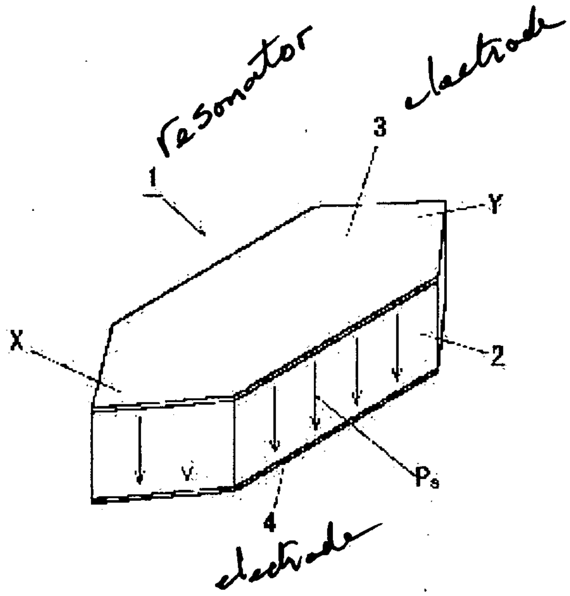
(54) PIEZOELECTRIC RESONATOR USED FOR FREQUENCY FILTER

(57)Abstract:
PROBLEM TO BE SOLVED: To improve the difference between a resonance frequency and an antiresonance frequency by applying polarization over the entire surface of a strip piezoelectric ceramic plate in a thickness direction and forming a taper part at both sides of a piezoelectric resonator.



SOLUTION: This piezoelectric resonator 1 forms a chevron-shaped taper part X at both end parts of a sheet-shaped piezoelectric ceramic plate 2 made of lead zirconate titanate(PZT) where electrodes 3 and 4 are formed on the surface and rear face of it and is formed by applying polarization (arrow Ps) over the entire surface in a thickness direction. In such a case, the chevron- shaped taper part X is formed by chipping both sides of both edges down into a taper shape at equal angles. When the strip piezoelectric resonator 1 is applied to a serial resonator and a parallel resonator, they utilizes a piezoelectric transverse effect in which an electric field direction and a polarization direction are different from a vibration direction, an electromechanical coupling coefficient is accordingly low, and Δf being the difference between a resonance frequency and an antiresonance frequency is made to be relative small. However, it is possible to make bandwidth wide by forming the taper part X at the both end parts.

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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The piezo resonator used for the frequency filter characterized by forming the taper section in the both ends while polarization is carried out in the thickness direction over the whole surface and equipping the principal plane of a front flesh side with an electrode.
[Claim 2] The piezo resonator used for the frequency filter according to claim 1 characterized by considering as the crest configuration in which the taper section deletes both sides in the shape of a taper with equiangular, and is formed.
[Claim 3] The piezo resonator according to claim 2 characterized by making the range of the dihedral angle theta of said crest configuration taper section into 10 degrees - 135 degrees.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the piezo resonator which is used for a wireless machine etc. and used for the ladder mold piezo-electricity frequency filter which combined two or more piezo resonators with the serial parallel.
[0002]
[Description of the Prior Art] This kind of frequency filter connects two or more steps of base unit circuits which come to make L type connection of the series resonance child of heavy-gage small capacity, and the parallel resonance child of light-gage large capacity, and consists of a configuration which contained this in the case. Each of this conventional resonator forms a whole surface electrode in both sides of a piezoelectric-ceramics plate, polarizes it in the thickness direction, and is constituted in the shape of a strip of paper. The parallel resonance child (P) and series resonance child (S) who consist of this piezo resonator constitute a frequency filter circuit, as drawing 15 shows.
[0003]
[Problem(s) to be Solved by the Invention] If it is in an above-mentioned strip-of-paper-like piezo resonator, as compared with the piezo resonator which used the piezo-electric transversal effect in which the direction of electric field and the direction of polarization differ from the oscillating direction, and used the piezo-electric longitudinal effect the direction of electric field and whose direction of polarization correspond with the oscillating direction for this reason, an electromechanical coupling coefficient (K31) is low. Moreover, deltaf which is the difference of resonance frequency fr and antiresonant frequency fa for this reason was comparatively small, and when it used for a frequency filter, the problem that bandwidth became narrow was produced. Especially, with the spread of digital communication, the filter of a broadband is called for and this has been a big solution technical problem in recent years. This invention aims at solving the trouble of such a strip-of-paper-like piezo resonator by the simple configuration.
[0004]
[Means for Solving the Problem] It is a piezo resonator used for the frequency filter characterized by forming the taper section in the both ends while polarization of this invention is carried out in the thickness direction over the whole surface and it equips the principal plane of a front flesh side with an electrode.
[0005] The Yamagata section which deletes both sides in the shape of a taper with equiangular, and is formed as this taper section is proposed. Here, from an experiment, difference deltaf of resonance frequency and antiresonant frequency became it is large and good, moreover, a mechanical strength can bear what made the range of the dihedral angle theta of this Yamagata section 10 degrees - 135 degrees at use, and it was checked that it is suitable as a resonator for the frequency filters of a

broadband.
[0006]
[Embodiment of the Invention] Drawing 1 and piezo-resonator 1a which starts this invention about 2 are explained. This piezo resonator 1 forms the crest configuration taper sections X and X in the both ends of the sheet metal-like piezoelectric-ceramics plate 2 which consists of titanic-acid lead zirconate (PZT) by which electrodes 3 and 4 were formed in the front flesh side, and is used as the series resonance child S who comes to carry out polarization (arrow Ps) in the thickness direction over the whole surface, and is applied to the frequency filter of drawing 15 , or a parallel resonance child P.
[0007] Here, means forming of this piezo resonator 1 is **(ed) in detail according to drawing 13 .
[0008] Pb 3O4, ZrO2, TiO2, CoO, Sb 2O3, and Nb2 O5 grade Pb {(Co 1/3Nb 2/3) Zr0.441 0.1 Ti0.459} O3+1.0 Gravity %Sb 2O3 So that it may become the empirical formula with which it is expressed Specified quantity weighing capacity is carried out and it prepares, and in a dry type vibration mill, it grinds primarily for 3 hours, and by dry type, it reaches two with a wet method for further 13 hours for 3 hours, carry out tertiary grinding of it, and let it be the mean particle diameter of about 0.6-0.9 micrometers, after carrying out temporary quenching of this in 800 ** for 2 hours, after desiccation and. The detailed powder obtained here is kneaded and it is dispersedly made a plastic matter. Next, using this plastic matter, with an extruding press machine, it extrudes in the shape of [of 0.8tmm] a sheet, and pierces to Oita of a 0.8mm[in thickness] x40mm angle. the shaping consistency at this time -- 4.6 - 4.9 g/cm3 it is . Next, baking is performed for 16 hours in a 1140 degrees C - 1180 degrees C atmospheric-air ambient atmosphere, and it considers as a piezoelectric-ceramics sintered compact. Grinding this sintered compact in the thickness direction with the front rear face, what is used as a series resonance child S carries out to 0.595mm in thickness, and what is used as a parallel resonance child P obtains the piezoelectric-ceramics plate 2 as 0.175mm in thickness.
[0009] Next, after carrying out application formation of the electrodes 3 and 4 with a silver paste and being burned on the front rear face of the piezoelectric-ceramics plate 2 at 720 degrees C, they are 20 degrees C and 30 kV/cm. Polarization (arrow Ps) of the direct current voltage is impressed and carried out for 10 minutes. Then, the obtained Oita component is cut in the shape of a strip of paper. If the example of a cutout dimension at this time is one of those which are used as a series resonance child S, it is made into die-length 3.28x width-of-face 0.66x thickness 0.595 (mm), and if it is in some which are used as a parallel resonance child P, let it be die-length 3.49x width-of-face 1.00x thickness 0.175 (mm). And the both sides of the both ends are further deleted in the shape of a taper with equiangular, the taper sections X and X of a crest configuration are formed, and a piezo resonator 1 is obtained.
[0010] As **(ed) and shown in drawing 1 and 2, electrodes 3 and 4 are formed in the principal plane of a front flesh side, the taper sections X and X are formed in both ends, and it crosses to the whole surface and the resonators S and P by which polarization was carried out are formed in the thickness direction. And these resonators S and P are applied to the frequency filter shown by drawing 15 .
[0011] although it was manufactured by the above-mentioned means and considered as theta= 45 degrees of dihedral angles of the taper sections X and X of a crest configuration -- a sample -- electrostatic capacity Cf in difference deltaf (kHz) of resonance frequency and antiresonant frequency, and 100kHz (pF), resonance frequency fr, antiresonant frequency fa, and the electromechanical coupling coefficient K31 of the piezo-electric transversal effect -- further -- Qm per -- it each measured. Consequently, it became as it is shown in Table 1. here -- front Naka -- the "conventional example" was formed with the same means -- ready -- the piezoelectric device at the time of using a strip-of-paper-like piezoelectric device [one] directly without deleting both ends is shown.
[0012]

[Table 1]

	従来例	形状変更	Δ
fa(kHz)	486.516	539.83	53.314
fr(kHz)	461.701	511.46	49.759
Δf(kHz)	24.815	28.37	3.555
K31(%)	35.2	35.6	0.4
Cf(pF)	55.5	49.5	-6
Qm	169	169	0

[0013] Here, the next table 2 shows the include angle of the dihedral angle theta the series resonance child's S taper section X and the relation of various properties it is unrelated from an above-mentioned configuration.

[0014]

[Table 2]

No	稜角 °	Δf kHz	Cf pF	fr kHz	fr×L Hzm	fa kHz	fa×L Hzm	K31 %	Qm
1	5	29.42	47.73	526.204	1726	555.627	1822	35.72	158
2	10	29.29	47.95	524.361	1720	553.652	1816	35.70	160
3	30	28.76	48.84	516.990	1696	545.754	1790	35.64	165
4	45	28.37	49.50	511.460	1678	539.830	1771	35.60	169
5	60	27.97	50.17	505.932	1659	533.906	1751	35.56	159
6	75	27.58	50.84	500.403	1641	527.983	1732	35.51	163
7	90	27.18	51.50	494.874	1623	522.059	1712	35.47	177
8	105	26.79	52.17	489.345	1605	516.135	1693	35.42	166
9	115	26.53	52.61	485.659	1593	512.186	1680	35.39	156
10	135	26.00	53.50	478.288	1569	504.287	1654	35.33	172
11	150	25.60	54.17	472.759	1551	498.364	1635	35.29	163
12	160	25.34	54.61	469.073	1639	494.414	1622	35.26	165
13	180	24.82	55.50	461.701	1514	486.516	1596	35.20	169

[0015] Next, the series resonance child S concerning this invention has drawing 3 - drawing 7 by making an above-mentioned result into a graph, respectively, and they show the relation between the include angle of the dihedral angle theta of the taper section X, and various properties.

[0016] Here, drawing 3 is resonance frequency fr. Antiresonant frequency fa It is the graph which shows the relation between difference deltaf and the include angle of the dihedral angle theta. What is in the piezo resonator 1 used as a series resonance child from this graph and Table 1, and was used as theta= 10 degrees - 135 degrees of dihedral angles is [difference deltaf of resonance frequency and antiresonant frequency] above about 26kHz and was good. Especially, at theta= 10 degrees - 45 degrees, it was checked that are set to about 28kHz or more, and deltaf shows the outstanding value and is suitable as a frequency filter.

[0017] Drawing 4 is a graph which shows the relation between electrostatic capacity Cf (f= 100kHz of test frequencies), and the include angle of the dihedral angle theta. This graph shows that electrostatic capacity Cf decreases, even if the include angle of the dihedral angle theta becomes small. By the way, the series resonance child S will be satisfactory, even if the one where electrostatic capacity is smaller is good and the include angle of the dihedral angle theta becomes small for this reason.

[0018] Drawing 5 is a graph which shows the relation between Qm and the include angle of the dihedral angle theta. Even if the include angle of the dihedral angle theta changes from this graph, it turns out that there is no big change in Qm.

[0019] Drawing 6 is a graph which shows the relation between a frequency constant (fr xL) and the include angle of the dihedral angle theta. This graph shows increasing a frequency-constant (fr xL) gradually with include-angle reduction of the dihedral angle theta. Here, it is L= regularity, therefore

this graph is a frequency fr. It corresponds to property change.

[0020] Drawing 7 is a graph which shows the relation between an electromechanical coupling coefficient K31 and the include angle of the dihedral angle theta. From this graph, if the taper section X is formed, an electromechanical coupling coefficient K31 will be increased gradually.

[0021] The next table 3 shows the include angle of the parallel resonance child's P dihedral angle theta and the relation of various properties it is unrelated from an above-mentioned configuration.

[0022]

[Table 3]

P	稜角 °	Δf kHz	Cf pF	fr kHz	fr×L Hzm	fa kHz	fa×L Hzm	K31 %	Qm
1	5	26.39	295.03	492.273	1615	518.661	1701	35.20	149
2	10	26.26	295.25	490.430	1609	516.686	1695	35.18	156
3	30	25.73	296.14	483.059	1584	508.788	1669	35.12	149
4	45	25.33	296.81	477.530	1566	502.864	1649	35.08	152
5	60	24.94	297.47	472.001	1548	496.940	1630	35.04	144
6	75	24.54	298.14	466.472	1530	491.017	1611	34.99	149
7	90	24.15	298.80	460.943	1512	485.093	1591	34.95	155
8	105	23.75	299.47	455.414	1494	479.169	1572	34.90	160
9	135	22.96	300.80	444.357	1457	467.321	1533	34.81	157
10	150	22.57	301.47	438.828	1439	461.398	1513	34.77	149
11	180	21.78	302.80	427.770	1403	449.550	1475	34.68	145

[0023] Drawing 8 - drawing 12 show in a graph the result above-mentioned [about what is used for the parallel resonance child P]. Here, drawing 8 is a graph which shows the relation between deltaf and the include angle of the dihedral angle theta. What is one of those which are used as a parallel resonance child, and was made into include-angle =10 degree-135 degree of the dihedral angle theta from this graph and Table 2 has difference deltaf of resonance frequency and antiresonant frequency as good as about 23kHz or more, and it was especially checked at 10 degrees - 45 degrees that deltaf shows the value which was set to about 25kHz or more, and was excellent, and is suitable as a broadband frequency filter.

[0024] Drawing 9 shows the relation between electrostatic capacity Cf (f= 100kHz of test frequencies), and the include angle of the dihedral angle theta. This graph shows that Cf decreases as the include angle of the dihedral angle theta becomes small.

[0025] Drawing 10 shows the relation between Qm and the include angle of the dihedral angle theta. This graph shows that there is no big change in Qm, even if it forms the taper section X.

[0026] Drawing 11 shows the relation between frequency constant fa xL and the include angle of the dihedral angle theta. This graph shows increasing frequency constant fa xL gradually as the include angle of the dihedral angle theta decreases.

[0027] Drawing 12 shows the relation between an electromechanical coupling coefficient K31 and the include angle of the dihedral angle theta. From this graph, if the taper section X is formed, an electromechanical coupling coefficient K31 will be increased gradually.

[0028] Thus, it turns out that the series resonance child S from whom thickness differs, and the parallel resonance child P all show the same property in relation with the include angle of the dihedral angle theta so that I may be understood by Tables 1 and 2 and drawing 3 - drawing 12 . moreover, Qm did not have a big change as compared with the time (ready -- the shape of a rectangle [one]) of there being no taper section X.

[0029] Furthermore, in order to check temperature dependence, it is resonance frequency fr. And it is attached to antiresonant frequency fa. A -35 degrees C - 85 degrees C temperature change is given to each sample which carried out the include angle of the dihedral angle theta if it was **. the difference of the maximum and minimum value -- resonance frequency fr at the time of ordinary temperature And when compared with antiresonant frequency fa, it is about 0.2 - 0.4%, and hardly changed as compared with the time (ready -- the shape of a rectangle [one]) of there being no taper section X. From this, it checked that the include angle of the dihedral angle theta was not what gives change to the temperature characteristic. Although aging after a reflow (230-250 degrees C) was investigated as a further heat-resistant index, knowledge which deteriorates by formation of the taper section X was not acquired.
[0030] It was checked that the well-organized resonance wave is shown without subresonance (spurious) occurring, when the output wave of each above-mentioned sample was investigated separately.
[0031] By the way, the taper section X is radicalized in the dihedral angle theta being 50 degrees or less, it becomes easy to suffer a loss, and a mechanical strength falls. For this reason, the minimum include angle of the dihedral angle theta is made into 10 degrees. Therefore, since it can be made into 135 degrees, if a upper limit is in the crest configuration taper section X, it becomes the optimal [the range of 10 degrees - 135 degrees of the dihedral angle theta] from an above-mentioned trial.
[0032] Furthermore, the circular tip Y is cut at the tip of the crest configuration taper section X, and you may make it prevent the deficit, as drawing 14 shows. In this case, the minimum include angle of the dihedral angle theta can be made still lower.
[0033] Furthermore, although an above-mentioned example indicates per [which made the taper section X the crest configuration] configuration, the taper section X of various configurations, such as a warhead form and a trapezoid, may be formed.
[0034] It ** and is in a strip-of-paper-like piezo resonator. These The piezo-electric transversal effect in which the direction of electric field and the direction of polarization differ from the oscillating direction is used. This sake, Although the problem that bandwidth became narrow was produced when deltaf which an electromechanical coupling coefficient is low and is the difference of resonance frequency fr and antiresonant frequency fa was comparatively small and it used for a frequency filter as compared with the piezo resonator using the piezo-electric longitudinal effect the direction of electric field and whose direction of polarization correspond with the oscillating direction Since deltaf increases by forming the taper section X in the both ends of a piezo resonator 1 as checked in the above experiment, an above-mentioned fault can be compensated.
[0035]
[Effect of the Invention] This invention is one of those by which polarization was carried out in the thickness direction over the whole surface of a strip-of-paper-like piezoelectric-ceramics plate, and formed the taper section X in the both ends of a piezo resonator, and, thereby, its difference deltaf of resonance frequency and antiresonant frequency improved.
[0036] When this strip-of-paper-like piezo resonator is applied to a series resonance child and a parallel resonance child, for this reason, these Used the piezo-electric transversal effect in which the direction of electric field and the direction of polarization differ from the oscillating direction, for this reason, the electromechanical coupling coefficient K31 was low, and deltaf which is the difference of resonance frequency fr and antiresonant frequency fa was made comparatively small, but By forming the taper section X in both ends, the fault of the piezo resonator used for the frequency filter of a broadband can be improved, and bandwidth of a frequency filter can be made large. And the taper section X can be easily formed by deleting in the shape of a taper at both ends etc., and, for this reason, manufacture can aim at improvement in a frequency filter property simple easily therefore.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the piezo resonator which is used for a wireless machine etc. and used for the ladder mold piezo-electricity frequency filter which combined two or more piezo resonators with the serial parallel.

[Translation done.]

PRIOR ART

[Description of the Prior Art] This kind of frequency filter connects two or more steps of base unit circuits which come to make L type connection of the series resonance child of heavy-gage small capacity, and the parallel resonance child of light-gage large capacity, and consists of a configuration which contained this in the case. Each of this conventional resonator forms a whole surface electrode in both sides of a piezoelectric-ceramics plate, polarizes it in the thickness direction, and is constituted in the shape of a strip of paper. The parallel resonance child (P) and series resonance child (S) who consist of this piezo resonator constitute a frequency filter circuit, as drawing 15 shows.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] This invention is one of those by which polarization was carried out in the thickness direction over the whole surface of a strip-of-paper-like piezoelectric-ceramics plate, and formed the taper section X in the both ends of a piezo resonator, and, thereby, its difference deltaf of resonance frequency and antiresonant frequency improved.
[0036] For this reason, when this strip-of-paper-like piezo resonator is applied to a series resonance child and a parallel resonance child, these use the piezo-electric transversal effect in which the direction of electric field and the direction of polarization differ from the oscillating direction. For this reason, an electromechanical coupling coefficient K31 is low, although deltaf which is the difference of resonance frequency fr and antiresonant frequency fa was made comparatively small, by forming the taper section X in both ends, the fault of the piezo resonator used for the frequency filter of a broadband can be improved, and bandwidth of a frequency filter can be made large. And the taper section X can be easily formed by deleting in the shape of a taper at both ends etc., and, for this reason, manufacture can aim at improvement in a frequency filter property simple easily therefore.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] If it is in an above-mentioned strip-of-paper-like piezo resonator, as compared with the piezo resonator which used the piezo-electric transversal effect in which the direction of electric field and the direction of polarization differ from the oscillating direction, and used the piezo-electric longitudinal effect the direction of electric field and whose direction of polarization correspond with the oscillating direction for this reason, an electromechanical coupling coefficient (K31) is low. Moreover, deltaf which is the difference of resonance frequency fr and antiresonant frequency fa for this reason was comparatively small, and when it used for a frequency filter, the problem that bandwidth became narrow was produced. Especially, with the spread of digital communication, the filter of a broadband is called for and this has been a big solution technical problem in recent years. This invention aims at solving the trouble of such a strip-of-paper-like piezo resonator by the simple configuration.

[Translation done.]

MEANS

[Means for Solving the Problem] It is a piezo resonator used for the frequency filter characterized by forming the taper section in the both ends while polarization of this invention is carried out in the thickness direction over the whole surface and it equips the principal plane of a front flesh side with an electrode.
[0005] The Yamagata section which deletes both sides in the shape of a taper with equiangular, and is formed as this taper section is proposed. Here, from an experiment, difference deltaf of resonance frequency and antiresonant frequency became it is large and good, moreover, a mechanical strength can bear what made the range of the dihedral angle theta of this Yamagata section 10 degrees - 135 degrees at use, and it was checked that it is suitable as a resonator for the frequency filters of a broadband.
[0006]
[Embodiment of the Invention] Drawing 1 and piezo-resonator 1a which starts this invention about 2 are explained. This piezo resonator 1 forms the crest configuration taper sections X and X in the both ends of the sheet metal-like piezoelectric-ceramics plate 2 which consists of titanic-acid lead zirconate (PZT) by which electrodes 3 and 4 were formed in the front flesh side, and is used as the series resonance child S who comes to carry out polarization (arrow Ps) in the thickness direction over the whole surface, and is applied to the frequency filter of drawing 15 , or a parallel resonance child P.
[0007] Here, means forming of this piezo resonator 1 is **(ed) in detail according to drawing 13 .
[0008] Pb 3O4, ZrO2, TiO2, CoO, Sb 2O3, and Nb2 O5 grade Pb {(Co 1/3Nb 2/3) Zr0.441 0.1 Ti0.459} O3+1.0 Gravity %Sb 2O3 So that it may become the empirical formula with which it is expressed Specified quantity weighing capacity is carried out and it prepares, and in a dry type vibration mill, it grinds primarily for 3 hours, and by dry type, it reaches two with a wet method for further 13 hours for 3 hours, carry out tertiary grinding of it, and let it be the mean particle diameter of about 0.6-0.9 micrometers, after carrying out temporary quenching of this in 800 ** for 2 hours, after desiccation and. The detailed powder obtained here is kneaded and it is dispersedly made a plastic matter. Next, using this plastic matter, with an extruding press machine, it extrudes in the shape of [of 0.8tmm] a sheet, and pierces to Oita of a 0.8mm[in thickness] x40mm angle. the shaping consistency at this time -- 4.6 - 4.9 g/cm3 it is . Next, baking is performed for 16 hours in a 1140 degrees C - 1180 degrees C atmospheric-air ambient atmosphere, and it considers as a piezoelectric-ceramics sintered compact. Grinding this sintered compact in the thickness direction with the front rear face, what is used as a series resonance child S carries out to 0.595mm in thickness, and what is used as a parallel resonance child P obtains the piezoelectric-ceramics plate 2 as 0.175mm in thickness.
[0009] Next, after carrying out application formation of the electrodes 3 and 4 with a silver paste and being burned on the front rear face of the piezoelectric-ceramics plate 2 at 720 degrees C, they are 20

degrees C and 30 kV/cm. Polarization (arrow Ps) of the direct current voltage is impressed and carried out for 10 minutes. Then, the obtained Oita component is cut in the shape of a strip of paper. If the example of a cutout dimension at this time is one of those which are used as a series resonance child S, it is made into die-length 3.28x width-of-face 0.66x thickness 0.595 (mm), and if it is in some which are used as a parallel resonance child P, let it be die-length 3.49x width-of-face 1.00x thickness 0.175 (mm). And the both sides of the both ends are further deleted in the shape of a taper with equiangular, the taper sections X and X of a crest configuration are formed, and a piezo resonator 1 is obtained.

[0010] As **(ed) and shown in drawing 1 and 2, electrodes 3 and 4 are formed in the principal plane of a front flesh side, the taper sections X and X are formed in both ends, and it crosses to the whole surface and the resonators S and P by which polarization was carried out are formed in the thickness direction. And these resonators S and P are applied to the frequency filter shown by drawing 15 .

[0011] although it was manufactured by the above-mentioned means and considered as theta= 45 degrees of dihedral angles of the taper sections X and X of a crest configuration -- a sample -- electrostatic capacity Cf in difference deltaf (kHz) of resonance frequency and antiresonant frequency, and 100kHz (pF), resonance frequency fr, antiresonant frequency fa, and the electromechanical coupling coefficient K31 of the piezo-electric transversal effect -- further -- Qm per -- it each measured. Consequently, it became as it is shown in Table 1. here -- front Naka -- the "conventional example" was formed with the same means -- ready -- the piezoelectric device at the time of using a strip-of-paper-like piezoelectric device [one] directly without deleting both ends is shown.

[0012]

[Table 1]

	従来例	形状変更	Δ
fa(kHz)	486.516	539.83	53.314
fr(kHz)	461.701	511.46	49.759
Δf(kHz)	24.815	28.37	3.555
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Qm	169	169	0

[0013] Here, the next table 2 shows the include angle of the dihedral angle theta the series resonance child's S taper section X and the relation of various properties it is unrelated from an above-mentioned configuration.

[0014]

[Table 2]

No	稜角 °	Δf kHz	Cf pF	fr kHz	fr×L Hzm	fa kHz	fa×L Hzm	K31 %	Qm
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4	45	28.37	49.50	511.460	1678	539.830	1771	35.60	169
5	60	27.97	50.17	505.932	1659	533.906	1751	35.56	159
6	75	27.58	50.84	500.403	1641	527.983	1732	35.51	163
7	90	27.18	51.50	494.874	1623	522.059	1712	35.47	177
8	105	26.79	52.17	489.345	1605	516.135	1693	35.42	166
9	115	26.53	52.61	485.659	1593	512.186	1680	35.39	156
10	135	26.00	53.50	478.288	1569	504.287	1654	35.33	172
11	150	25.60	54.17	472.759	1551	498.364	1635	35.29	163
12	160	25.34	54.61	469.073	1539	494.414	1622	35.26	165
13	180	24.82	55.50	461.701	1514	486.516	1596	35.20	169

[0015] Next, the series resonance child S concerning this invention has drawing 3 - drawing 7 by making an above-mentioned result into a graph, respectively, and they show the relation between the include angle of the dihedral angle theta of the taper section X, and various properties.
[0016] Here, drawing 3 is resonance frequency fr. Antiresonant frequency fa It is the graph which shows the relation between difference deltaf and the include angle of the dihedral angle theta. What is in the piezo resonator 1 used as a series resonance child from this graph and Table 1, and was used as theta= 10 degrees - 135 degrees of dihedral angles is [difference deltaf of resonance frequency and antiresonant frequency] above about 26kHz and was good. Especially, at theta= 10 degrees - 45 degrees, it was checked that are set to about 28kHz or more, and deltaf shows the outstanding value and is suitable as a frequency filter.
[0017] Drawing 4 is a graph which shows the relation between electrostatic capacity Cf (f= 100kHz of test frequencies), and the include angle of the dihedral angle theta. This graph shows that electrostatic capacity Cf decreases, even if the include angle of the dihedral angle theta becomes small. By the way, the series resonance child S will be satisfactory, even if the one where electrostatic capacity is smaller is good and the include angle of the dihedral angle theta becomes small for this reason.
[0018] Drawing 5 is a graph which shows the relation between Qm and the include angle of the dihedral angle theta. Even if the include angle of the dihedral angle theta changes from this graph, it turns out that there is no big change in Qm.
[0019] Drawing 6 is a graph which shows the relation between a frequency constant (fr xL) and the include angle of the dihedral angle theta. This graph shows increasing a frequency constant (fr xL) gradually with include-angle reduction of the dihedral angle theta. Here, it is L= regularity, therefore this graph is a frequency fr. It corresponds to property change.
[0020] Drawing 7 is a graph which shows the relation between an electromechanical coupling coefficient K31 and the include angle of the dihedral angle theta. From this graph, if the taper section X is formed, an electromechanical coupling coefficient K31 will be increased gradually.
[0021] The next table 3 shows the include angle of the parallel resonance child's P dihedral angle theta and the relation of various properties it is unrelated from an above-mentioned configuration.
[0022]
[Table 3]

P	稜角 °	Δf kHz	Cf pF	fr kHz	fr×L Hzm	fa kHz	fa×L Hzm	K31 %	Qm
1	5	26.39	295.03	492.273	1615	518.661	1701	35.20	149
2	10	26.26	295.25	490.430	1609	516.686	1695	35.18	156
3	30	25.73	296.14	483.059	1584	508.788	1669	35.12	149
4	45	25.33	296.81	477.530	1566	502.864	1649	35.08	152
5	60	24.94	297.47	472.001	1548	496.940	1630	35.04	144
6	75	24.54	298.14	466.472	1530	491.017	1611	34.99	149
7	90	24.15	298.80	460.943	1512	485.093	1591	34.95	155
8	105	23.75	299.47	455.414	1494	479.169	1572	34.90	160
9	135	22.96	300.80	444.357	1457	467.321	1533	34.81	157
10	150	22.57	301.47	438.828	1439	461.398	1513	34.77	149
11	180	21.78	302.80	427.770	1403	449.550	1475	34.68	145

[0023] Drawing 8 - drawing 12 show in a graph the result above-mentioned [about what is used for the parallel resonance child P]. Here, drawing 8 is a graph which shows the relation between deltaf and the include angle of the dihedral angle theta. What is one of those which are used as a parallel

resonance child, and was made into include-angle =10 degree-135 degree of the dihedral angle theta from this graph and Table 2 has difference deltaf of resonance frequency and antiresonant frequency as good as about 23kHz or more, and it was especially checked at 10 degrees - 45 degrees that deltaf shows the value which was set to about 25kHz or more, and was excellent, and is suitable as a broadband frequency filter.

[0024] Drawing 9 shows the relation between electrostatic capacity Cf (f= 100kHz of test frequencies), and the include angle of the dihedral angle theta. This graph shows that Cf decreases as the include angle of the dihedral angle theta becomes small.

[0025] Drawing 10 shows the relation between Qm and the include angle of the dihedral angle theta. This graph shows that there is no big change in Qm, even if it forms the taper section X.

[0026] Drawing 11 shows the relation between frequency constant fa xL and the include angle of the dihedral angle theta. This graph shows increasing frequency constant fa xL gradually as the include angle of the dihedral angle theta decreases.

[0027] Drawing 12 shows the relation between an electromechanical coupling coefficient K31 and the include angle of the dihedral angle theta. From this graph, if the taper section X is formed, an electromechanical coupling coefficient K31 will be increased gradually.

[0028] Thus, it turns out that the series resonance child S from whom thickness differs, and the parallel resonance child P all show the same property in relation with the include angle of the dihedral angle theta so that I may be understood by Tables 1 and 2 and drawing 3 - drawing 12 . moreover, Qm did not have a big change as compared with the time (ready -- the shape of a rectangle [one]) of there being no taper section X.

[0029] Furthermore, in order to check temperature dependence, it is resonance frequency fr. And it is attached to antiresonant frequency fa. A -35 degrees C - 85 degrees C temperature change is given to each sample which carried out the include angle of the dihedral angle theta if it was **. the difference of the maximum and minimum value -- resonance frequency fr at the time of ordinary temperature And when compared with antiresonant frequency fa, it is about 0.2 - 0.4%, and hardly changed as compared with the time (ready -- the shape of a rectangle [one]) of there being no taper section X. From this, it checked that the include angle of the dihedral angle theta was not what gives change to the temperature characteristic. Although aging after a reflow (230-250 degrees C) was investigated as a further heat-resistant index, knowledge which deteriorates by formation of the taper section X was not acquired.

[0030] It was checked that the well-organized resonance wave is shown without subresonance (spurious) occurring, when the output wave of each above-mentioned sample was investigated separately.

[0031] By the way, the taper section X is radicalized in the dihedral angle theta being 50 degrees or less, it becomes easy to suffer a loss, and a mechanical strength falls. For this reason, the minimum include angle of the dihedral angle theta is made into 10 degrees. Therefore, since it can be made into 135 degrees, if a upper limit is in the crest configuration taper section X, it becomes the optimal [the range of 10 degrees - 135 degrees of the dihedral angle theta] from an above-mentioned trial.

[0032] Furthermore, the circular tip Y is cut at the tip of the crest configuration taper section X, and you may make it prevent the deficit, as drawing 14 shows. In this case, the minimum include angle of the dihedral angle theta can be made still lower.

[0033] Furthermore, although an above-mentioned example indicates per [which made the taper section X the crest configuration] configuration, the taper section X of various configurations, such as a warhead form and a trapezoid, may be formed.

[0034] It ** and is in a strip-of-paper-like piezo resonator. These The piezo-electric transversal effect in which the direction of electric field and the direction of polarization differ from the oscillating

direction is used. This sake, Although the problem that bandwidth became narrow was produced when deltaf which an electromechanical coupling coefficient is low and is the difference of resonance frequency fr and antiresonant frequency fa was comparatively small and it used for a frequency filter as compared with the piezo resonator using the piezo-electric longitudinal effect the direction of electric field and whose direction of polarization correspond with the oscillating direction Since deltaf increases by forming the taper section X in the both ends of a piezo resonator 1 as checked in the above experiment, an above-mentioned fault can be compensated.

[Translation done.]

DESCRIPTION OF DRAWINGS

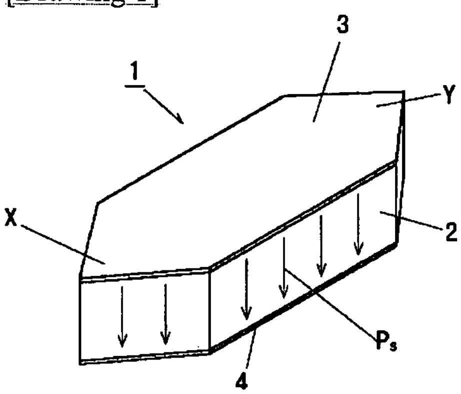
[Brief Description of the Drawings]
[Drawing 1] It is the perspective view of the piezo resonator 1 concerning this invention.
[Drawing 2] It is the top view of a piezo resonator 1.
[Drawing 3] The graph which shows the relation between deltaf and the dihedral angle theta in the piezo resonator 1 used for the series resonance child S
[Drawing 4] It sets to the piezo resonator 1 used for the series resonance child S, and is the electrostatic capacity Cf in 100kHz. Graph which shows the relation of the dihedral angle theta
[Drawing 5] It sets to the piezo resonator 1 used for the series resonance child S, and is Qm. Graph which shows the relation of the dihedral angle theta
[Drawing 6] The graph which shows the relation between a frequency constant (fr xL) and the dihedral angle theta in the piezo resonator 1 used for the series resonance child S
[Drawing 7] The graph which shows an electromechanical coupling coefficient K31 and the relation of the dihedral angle theta in the piezo resonator 1 used for the series resonance child S
[Drawing 8] The graph which shows the relation between deltaf and the dihedral angle theta in the piezo resonator 1 used for the parallel resonance child P
[Drawing 9] It sets to the piezo resonator 1 used for the parallel resonance child P, and is electrostatic capacity Cf. Graph which shows the relation of the dihedral angle theta
[Drawing 10] It sets to the piezo resonator 1 used for the parallel resonance child P, and is Qm. Graph which shows the relation of the dihedral angle theta
[Drawing 11] The graph which shows the relation between a frequency constant (fa xL) and the dihedral angle theta in the piezo resonator 1 used for the parallel resonance child P
[Drawing 12] The graph which shows an electromechanical coupling coefficient K31 and the relation of the dihedral angle theta in the piezo resonator 1 used for the parallel resonance child P
[Drawing 13] It is the flow chart Fig. showing a process.
[Drawing 14] It is the top view of the piezo resonator 1 of a configuration of having formed the circular tip Y at the tip of the crest configuration taper section X.
[Drawing 15] It is a frequency filter circuit Fig. using the parallel resonance child P who consists of a piezo resonator, and the series resonance child S.
[Description of Notations]
1 Piezo Resonator
2 Piezoelectric-Ceramics Plate
3 Electrode
4 Electrode
X Taper section

S Series resonance child
P Parallel resonance child

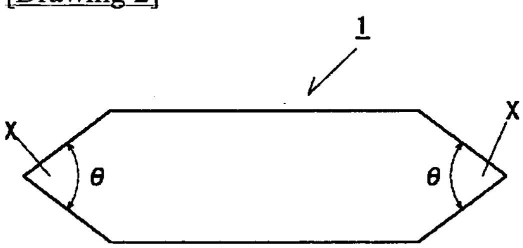
[Translation done.]

DRAWINGS

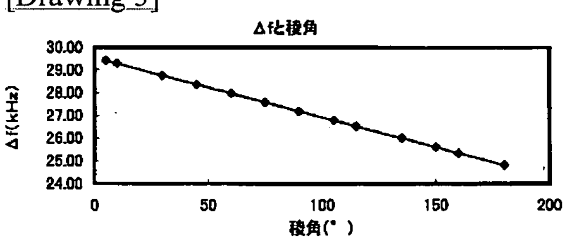
[Drawing 1]



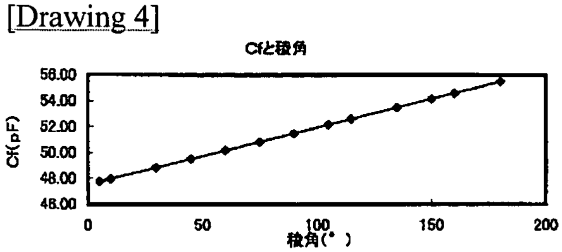
[Drawing 2]



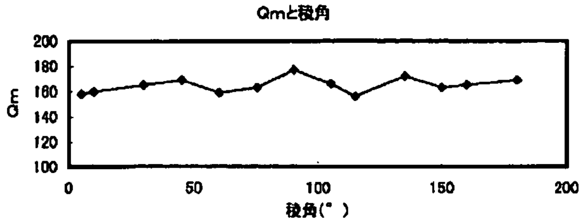
[Drawing 3]



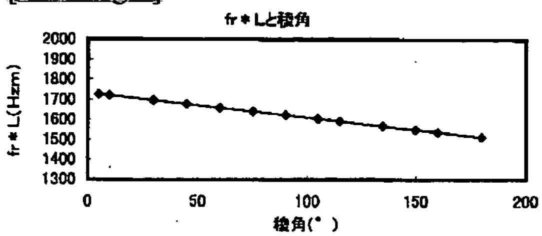
[Drawing 4]



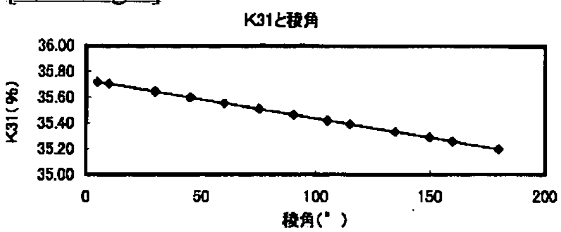
[Drawing 5]



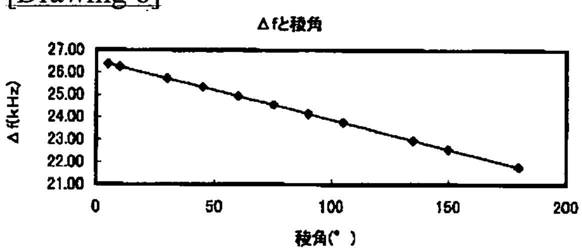
[Drawing 6]



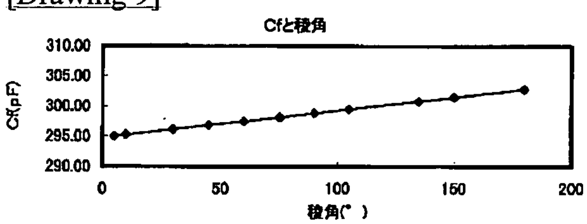
[Drawing 7]



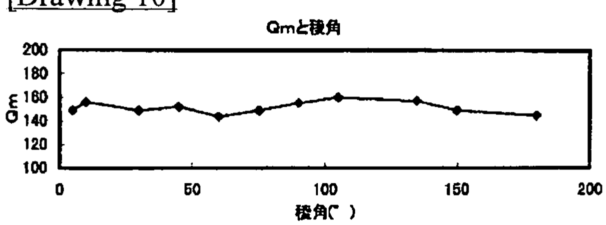
[Drawing 8]



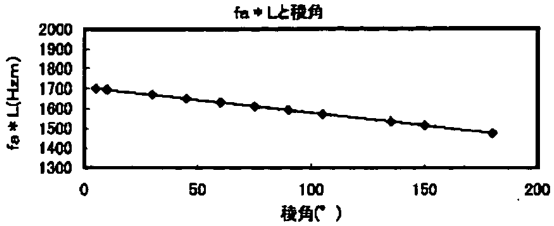
[Drawing 9]



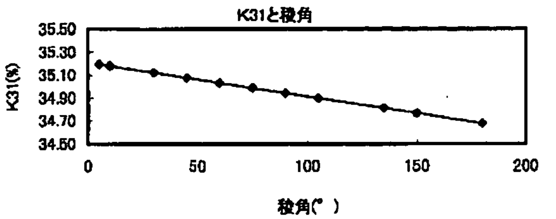
[Drawing 10]



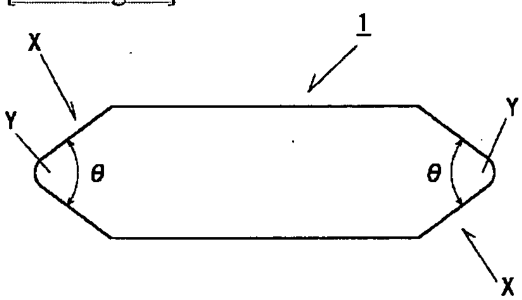
[Drawing 11]



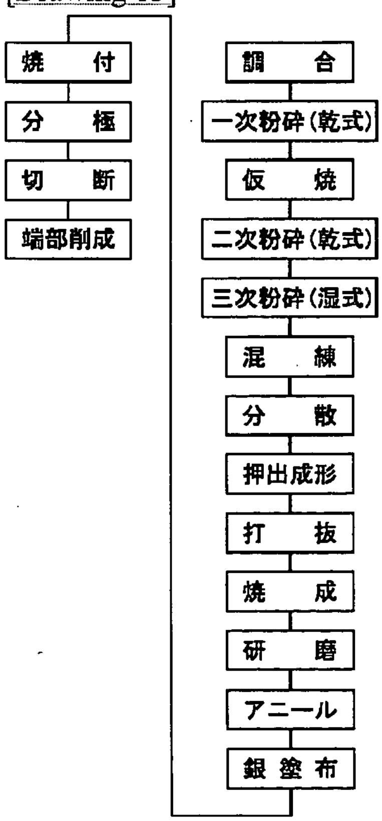
[Drawing 12]



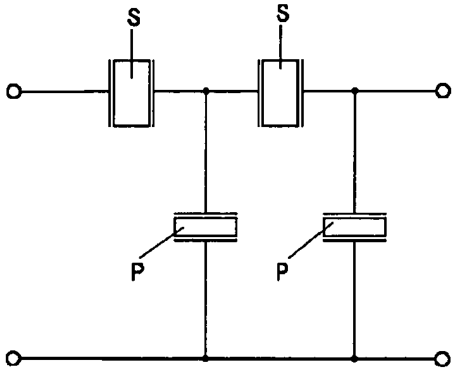
[Drawing 14]



[Drawing 13]



[Drawing 15]



[Translation done.]